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COMPARISON OF SERIES FROM THE AVAR AGE BY CLUSTERING

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Abstract

Author determined the weighted mean and standard deviation of 14 measurements from 28 Avar-Period series dug up in Hungary. Their comparison with the HOWELLS mean-sigmas manifested significant differences in 13 male and 8 female characters.

With the help of computer the PENROSE distance were determined (of size and shape; generalized) and by simple (single-link) and complex (complete-link) clustering, the distances between the various series were demonstrated.

Key-words: Avar-Period series, mean sigma. PENROSE distances, clustering

Introduction

The evaluation of human bone remains from the many Avar-Period cemeteries excavated on Hungarian territory was firstly carried out from the viewpoint of taxonomy and facial-flatness. Synthesizing studies provide survey on the sites (ÉRY, 1968) and on the results of the biometrical comparison of the 6th–12th century cemeteries (ÉRY, 1970). The latter publication comprises the studies on 10 measurements and 7 indices of 34 male and female series, taking into account the mean sigmas of VAN BORK-FELTKAMP, HOWELLS and ALEKSEEV–DEBEC. The 909 male and 779 female skeletons of the 16 Avar-Period series, and the 18 series belonging to the time of the Hungarian conquest and the subsequent Arpadian Age practically form a combined europid sample (with the exception of the Üllő I and II sites). However, they provide less information on the possible differences between Avar Age series.

With the purpose to determine this, similar studies were accomplished on 28 Avar-Period series, mainly originating from the area between the rivers Danube and Tisza.

Materials and methods

The findings from the following cemeteries were taken into consideration:

Adorján-Highway (Adorján-A) and Adorján-farm (Adorján-F) (BARTUCZ–FARKAS, 1957), Alattyán-Tulát (WENGER, 1957), Áporkai-Ürbőpuszta (LIPTÁK, 1951), Bačka-Topola (FARKAS–MARCSIK, under publication), Csákberény (TÓTH, 1962), Előszállás-Bajcsihegy (WENGER, 1967), Győr (NEMESKÉRI, 1943), Homokmégy–Halom (LIPTÁK, 1957), Jànoshida–Tótkérpuszta (WENGER, 1953), Kecel-I (LIPTÁK, 1954), Kékesd (WENGER, 1968), Kiskőrös-Pohibuj (LIPTÁK, 1956), Kunszállás (LIPTÁK–VARGA, 1971), Madaras (LIPTÁK–MARCSIK, 1976), Mélykút (MARCSIK, 1971), Mosonszentjános (LIPTÁK, 1959), Szolnok–Rákóczifalva (LIPTÁK–MARCSIK, 1975), Sükösd (KŐHEGYI–MARCSIK, 1971), Szeged–Fehértó–A (LIPTÁK–VÁMOS, 1969), Szeged–Kúndomb (LIPTÁK–MARCSIK, 1966), Szeged–Makkoserdő (VÁMOS, 1973), Szekszárd–Palánk (LIPTÁK, 1974), Szentes–Kaján (WENGER, 1955), Szarvas–Kákapuszta (LIPTÁK–MARCSIK, 1971), Tiszavárkony (LIPTÁK, 1958), Üllő-I, and II (LIPTÁK, 1955).

The analysis was carried out on the basis of the craniometric numeration according to MARTIN–SALLER (1956), with the following measurements: 1, 8, 9, 17, 38, 45, 47, 48, 51, 52, 54, 55, 66 and 69. The series in which any of the 14 measurements was missing or the individual data could not be substituted were not included in the joint sample.

According to our basic conception the 28 Avar-Period series were regarded as a single population. As the first step the sample element numbers (n), the arithmetic mean ($\bar{x}$) and standard deviation (s) were repeatedly determined for all 14 types from the basis data by sex. The same calculation was carried out for literary data for which above parameters had been given. Taking into account these parameters, we gained the combined sample element numbers (N), the weighted arithmetic mean ($\bar{x}$) and the wighted standard deviation (S) according to character and sex. These are given in Table 1. An R-40 type computer was used.

To determine the variation and their degree between the HOWELLS-type mean-sigmas and standard deviations obtained for the Avar-Period findings, the chi-square probe of Rao was used:

$$\overset{2}{\varkappa} = \frac{n.s^2}{\varrho^2},$$

where n = the number of the appropriate characters in the combined sample; s^2 = variance of the combined sample; and ϱ^2 = the HOWELLS-type mean-sigma referring to the appropriate character.

The difference obtained on the basis of the $\sqrt{2.\varkappa^2} - \sqrt{2n-1}$ formula follows normal distribution above 30 degrees of freedom around O mean, with unit standard deviation. On this basis, if the above difference value reaches 2 and 3, the difference should be regarded as significant and highly significant respectively (THOMA, 1957).

The results of calculations are presented in Table 2.

For the calculation of the PENROSE-distances the combined sample's standard deviation was regarded as Avar-Period mean-sigma, in our opinion, the HOWELLS-type mean-sigma values published in the literature (THOMA, 1957) cannot be applied to the Avar-Period series, because the standard deviations regarded as standards were only calculated from europid-type series. Furthermore, the standard deviation values are not distinguished according to sexes.

Also by means of computer, the PENROSE-distances (KNUSSMANN, 1967) — according to size, shape, and generalized — between the samples were determined separately for males and females. On the basis of these, simple (single-link) and complex (complete-link) clusters were formed by computer. The results are given in Figures 1–12.

In the Figures the following symbols were used: MCH means the size distances for males, FCH the same for females; MCF (males) and FCF (females) for shape distances; MCR (males) and FCR (females) for the generalized distances.

With single-link clustering those two samples were regarded as belonging to one group between which a linkage could be determined whose each element reaches a given level.

The complete-link relation brings into prominence the groups in which each sample is in close connection with the others. This method regards two samples as belonging to one group if both represent a similarity level higher than a given level with every element of the group, and with each other.

Results

Table 2 gives information on the differences between the standard deviation values of the HOWELLS-type mean-sigmas and those of the Avar-Period combined sample.

In the case of males significant difference was not obtained concerning the width of the lower jaw (go-go); for the other 13 parameters the standard deviations of the Avar Age findings show greater variation than the mean-sigmas given by

HOWELLS. As regards females, significance was in case of five measurements: maximum length of the skull, minimum forehead width, morphologic face height, height and width of orbita.

We concluded that the differences of the standard deviations regarding males could first of all arise from the mongolid character and unambigously proves our assumption, that the HOWELLS-type mean-sigmas calculated for europids cannot always be applied to the Avar-Period series, which comprise mongoloid elements.

In the case of females, on the other hand, the slighter variations may arise from the fact that the HOWELLS-type values refer to males.

As to the size distances (MCH) for the male findings the similarily was the most striking between the Homokmégy and Kecel-I sites, while the findings excavated at Rákoczifalva could only be linked to the rest of the samples at the 0.60 level. On the basis of the size distances, further sites can also be divided into groups (Fig. 1.)

On the basis of the size distances (FCH) the female skeletons show the greatest similarity at the 0.95 level, in the case of the Homokmégy, Kecel–I and Üllő–II series, while the slightest link, 0.65, to the rest of the samples was found from the findings at Szarvas (Fig. 2).

With the complete-link clustering an entirely separate group is formed by the male findings of the mainly mongolid series from Bačka–Topola, Madaras, Szarvas, Kunszállás and Mosonszentjános. The series Adorján–F segregates. The group of findings from Rákóczifalva is entirely different from every other sample. The rest of the series can be ranked into a larger group. Within the first and third groups at a lower level, subgroups segregating from each other were observed (Fig. 3).

With compleste clustering in the case of the female findings, the Avar Age findings from Szeged–Makkoserdő and Szarvas can sharply be separated, and the rest of the series can be divided into two large groups, within which subgroups can be distinguished (Fig. 4).

Fig. 5 gives information on the shape distances regarding males (MCF). Further three series (Tiszavárkony, Üllő–I and II) could be linked to the group formed by the two sites (Homokmégy and Kecel–I) connectible on the basis of the size distances. In this case, too, the Avar Age findings from Rákóczifalva were those less connectible to the rest of the series. Apart from the aforesaid, further four major groups could be separated.

In the case of females (FCF) the highest (of 0.95 level) and lowest (0.65 level) linkage could be formed in entire similarity to the results obtained regarding the size distances (Fig. 6).

With the complete-link clusterirg the male findings (Fig. 7) could be divided into a smaller (Bačka–Topola, Mélykút, Madaras, Kunszállás, Mosonszentjános) and a larger group comprising the majority of the series. The Rákóczifalva series forms a completely separate one. The result of the clustering is greatly similar to the result of the complete-link clustering gained for the size distances, only the Adorján-F site does not form a separate group as regards shape distance.

Fig. 8 shows the sketch of the complete-link clustering of the shape distances in the female series. On this basis, the samples can be divided into two completely different groups. Within the larger group, considering levels between 0.30 and 0.75, five subgroups of findings could be separated, being in connection with each other.

Fig. 9 demonstrates the obtained information on the relationship of the male series (MCR) on the basis of the generalized distances. It could be determined that the

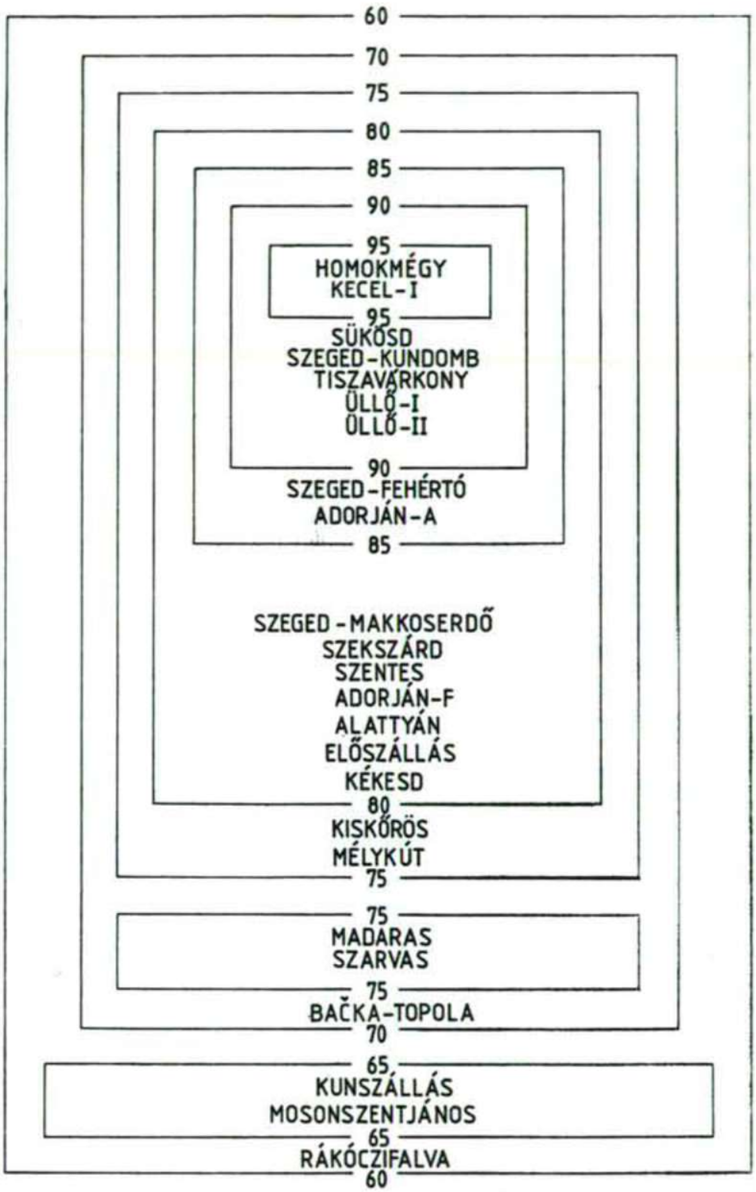

Fig. 1. Results of simple clustering on the basis of the size distances regarding male findings (MCH)

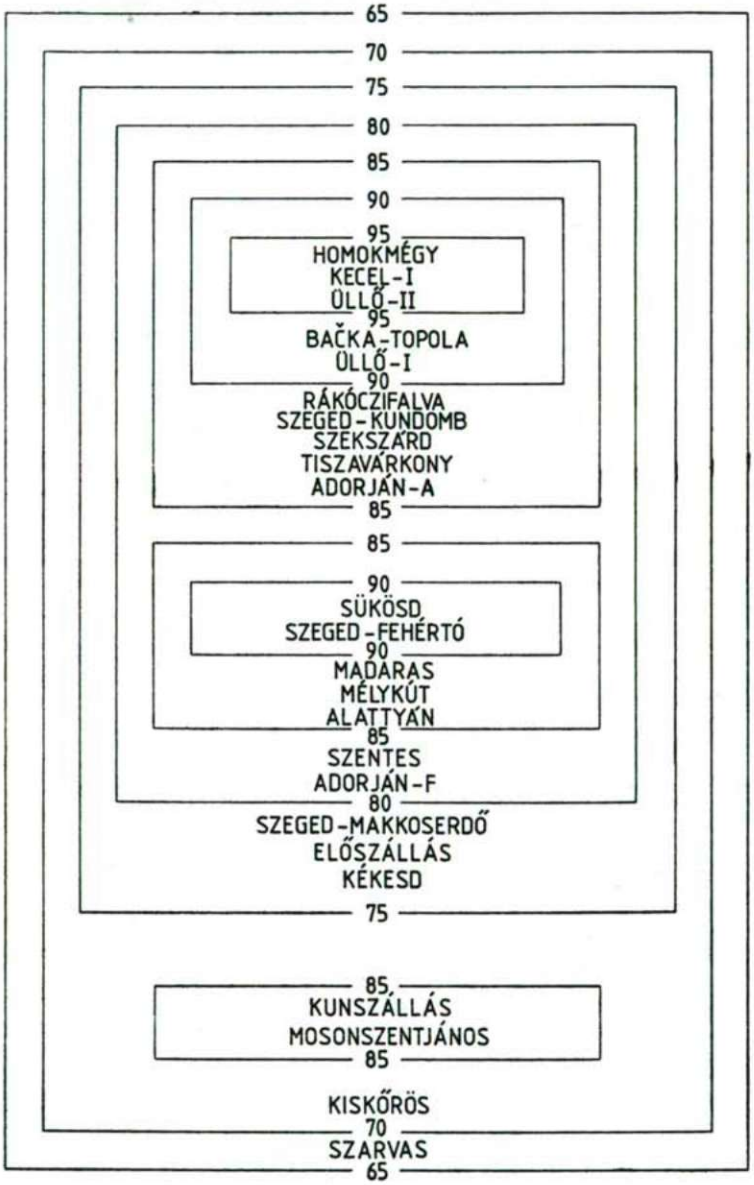

Fig. 2. Result of simple clustering on the basis of the size distances regarding female findings (FCH)

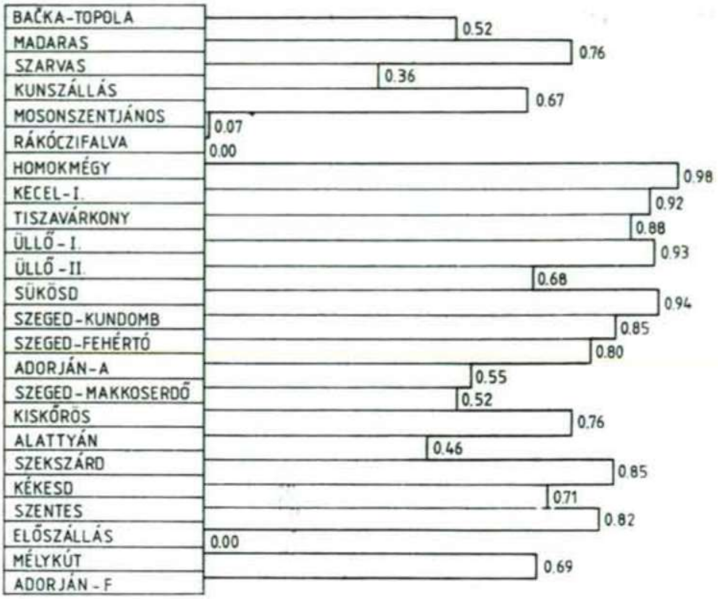

Fig. 3. Result of complex clustering on the basis of the size distances regarding male findings (MCH)

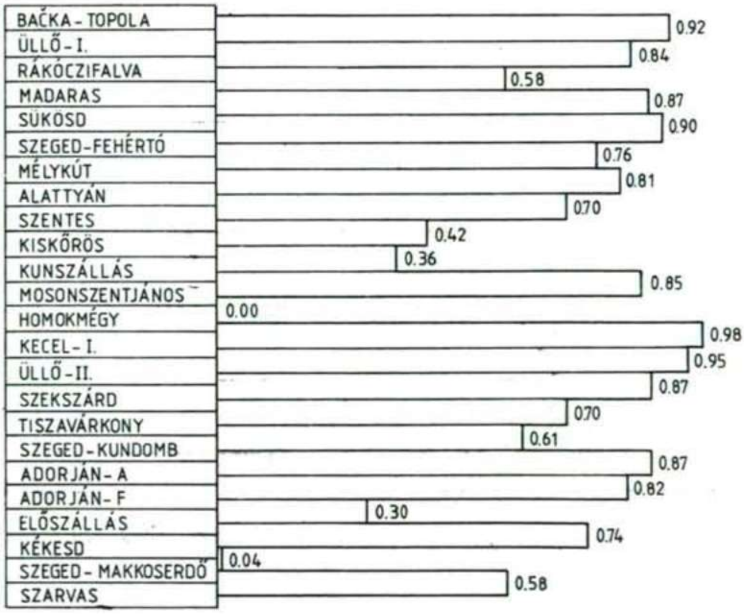

Fig. 4. Result of complex clustering on the basis of the size distances regarding female findings (FCH)

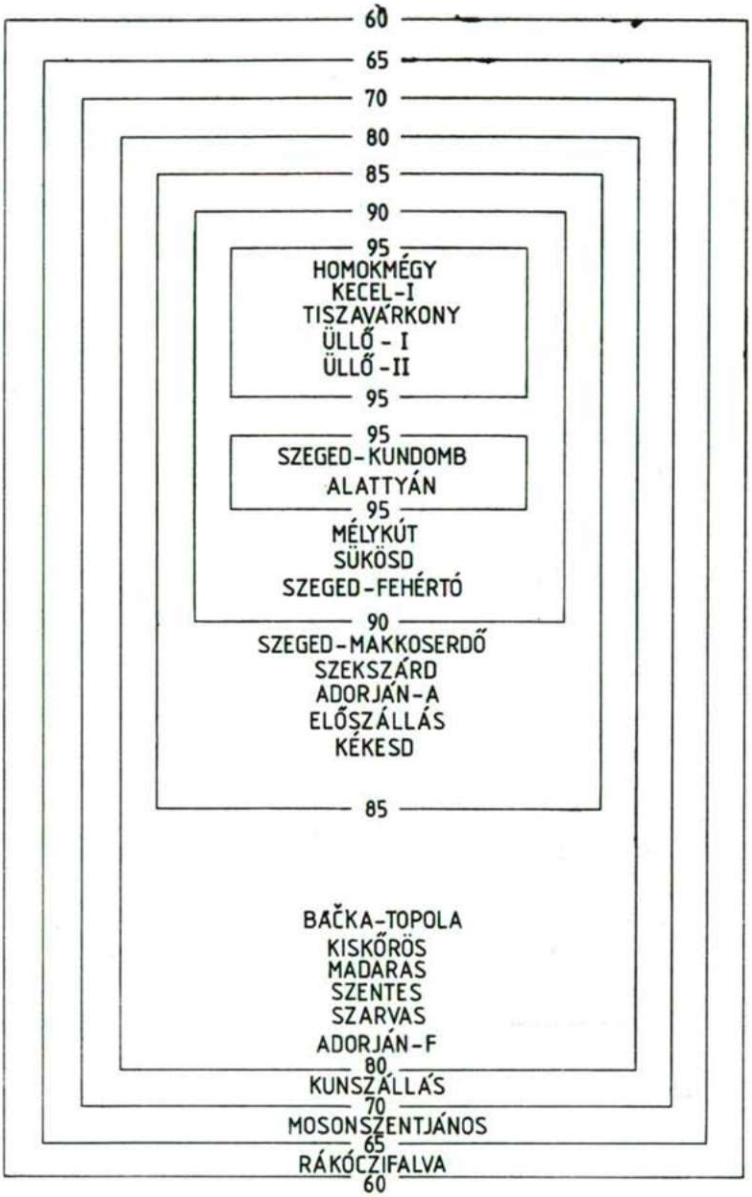

Fig. 5. Result of simple clustering on the basis of the shape distances regarding male findings (MCF)

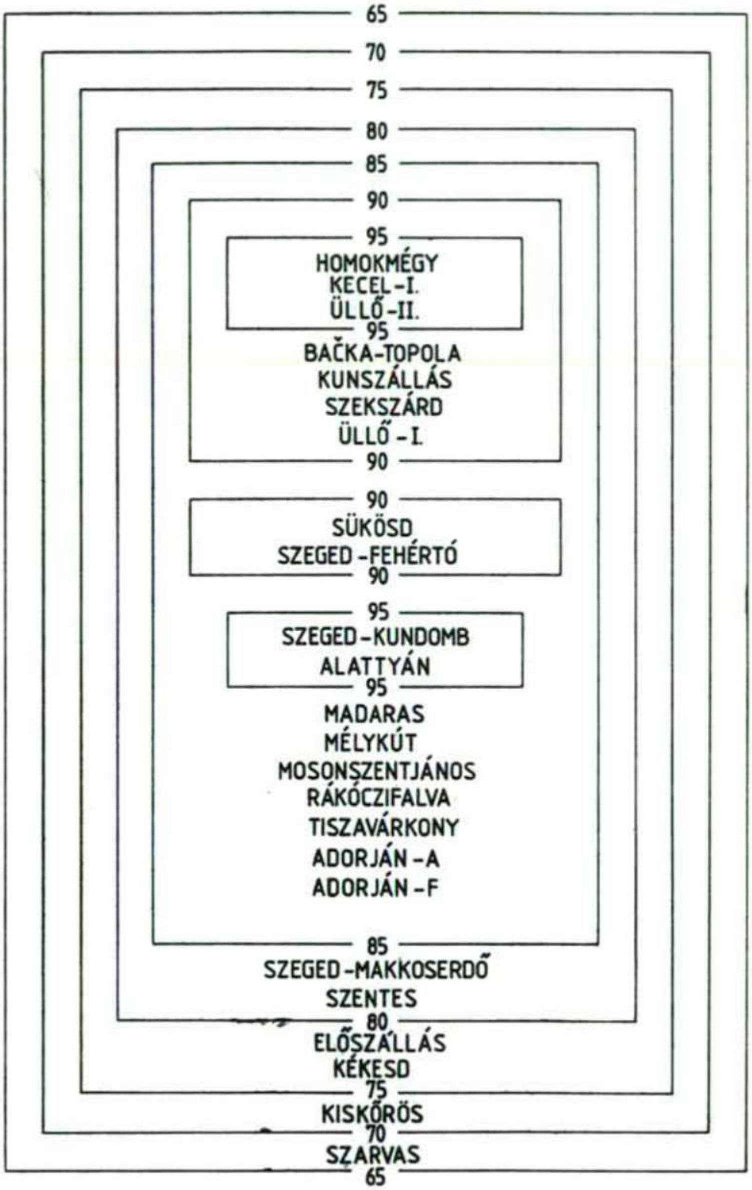

Fig. 6. Result of simple clustering on the basis of the shape distances regarding female findings (FCF)

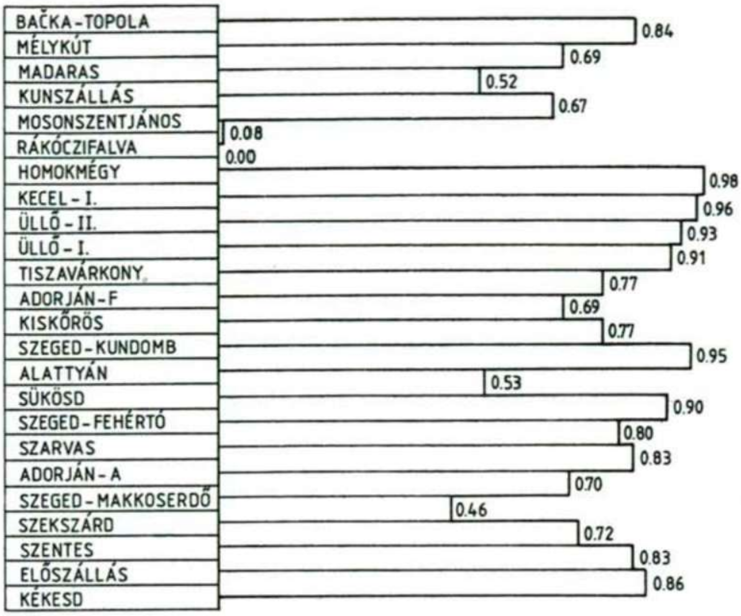

Fig. 7. Result of complex clustering on the basis of the shape distances regarding male findings (MCF)

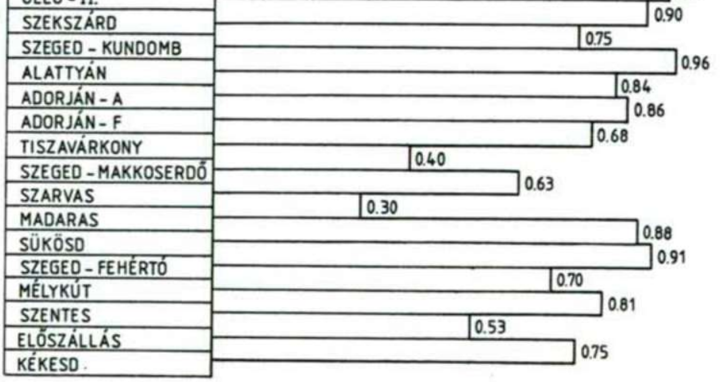

Fig. 8. Result of complex clustering on the basis of the shape distances regarding female findings (FCF)

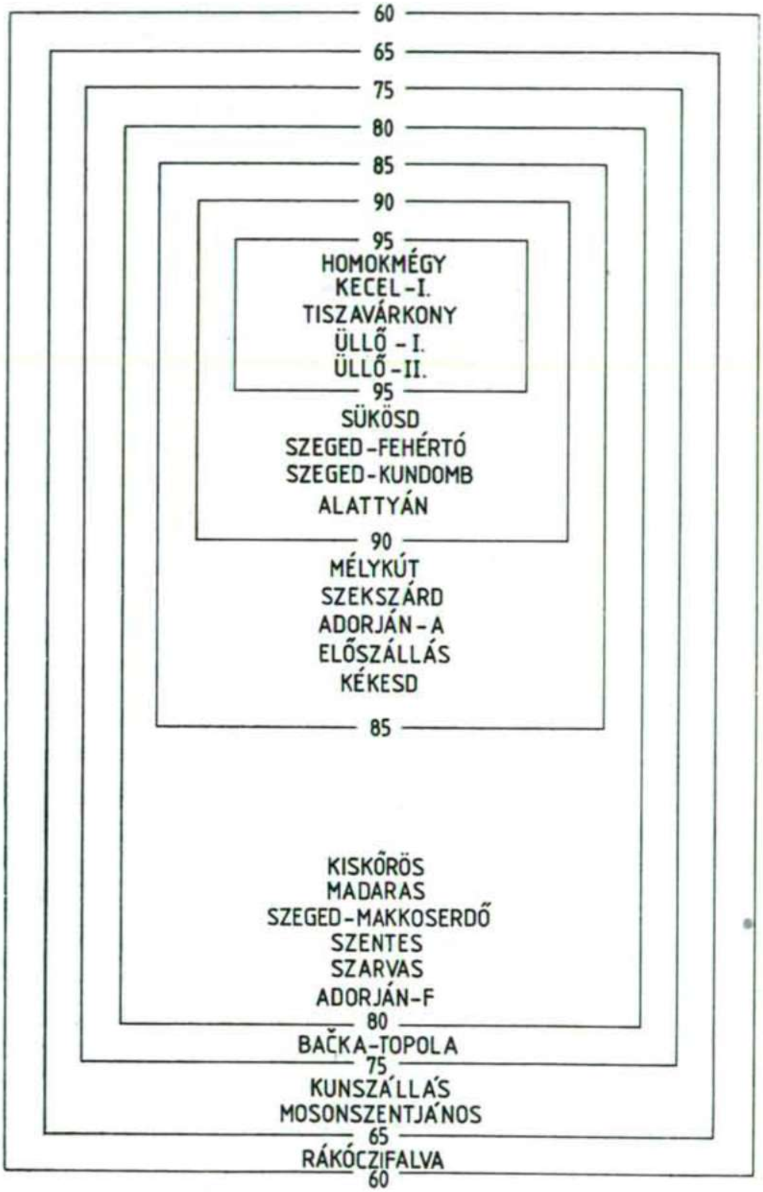

Fig. 9. Result of simple clustering on the basis of the generalized distances regarding male findings (MCR)

Fig. 10. Result of simple clustering on the basis of the generalized distances regarding female findings (FCR)

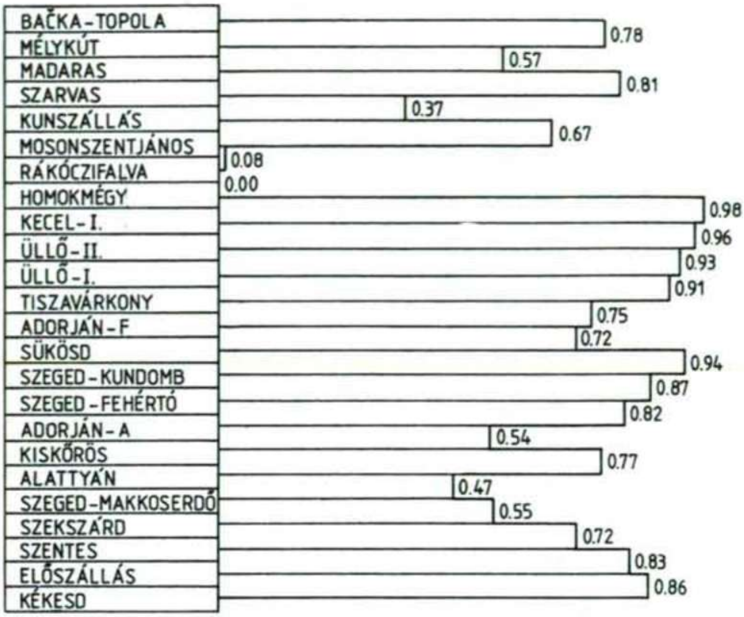

Fig. 11. Result of complex clustering on the basis of the generalized distances regarding male findings (MCR)

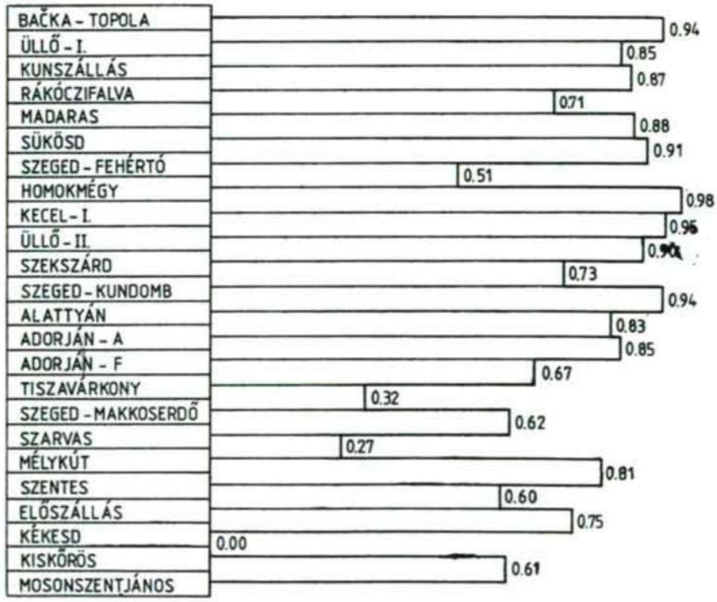

Fig. 12. Result of complex clustering on the basis of the generalized distances regarding female findings (FCR)

following sites could be linked at the 0.95 level: Homokmégy, Kecel–I, Tiszavárkony, Üllő–I and II, while the findings from Rákóczifalva entirely differ from the rest of the samples at the 0.60 level.

Fig. 10 shows the single-link clustering of the generalized distances in the case of the female series. Three sites could be linked at the 0.95 level (Homokmégy, Kecel–I, Üllő–II), while the findings from Szarvas could only be linked to every other series at the 0.65 level.

The result of the complete-link clustering in regard to the males is shown in Fig. 11. The series can practically be divided into two large groups, the boundary line is formed by the Rákóczifalva findings. Distribution into four subgroups was possible within the larger group.

Fig. 12 demonstrates the female series in a similar manner. Here, the Mosonszentjános series is completely separated, the rest of the finding groups are in relationship with each other to a lower or higher degree and form a connected group. Nevertheless, at least six subunits can be separated within this large group.

Table 1. Parameters of the combined Avar Period sample

Males				Females			
No. Martin	N	$\bar{x}$	s	No. Martin	N	$\bar{x}$	s
1.	724	182.45	6.83	1.	611	174.68	6.05
8.	724	144.31	6.45	8.	641	140.42	5.97
9.	786	97.11	4.61	9.	697	93.99	4.28
17.	513	131.21	5.92	17.	475	125.30	5.60
38.	407	1421.00	115.16	38.	365	1288.70	105.98
45.	515	134.93	5.78	45.	476	126.13	5.59
47.	498	119.60	6.84	47.	428	111.72	6.21
48.	658	70.98	4.65	48.	589	67.17	4.67
51.	691	40.61	1.94	51.	630	39.32	1.81
52.	695	33.69	2.38	52.	636	33.51	2.02
54.	650	25.75	1.93	54.	578	24.72	1.99
55.	675	51.95	3.71	55.	605	49.44	3.24
66.	573	102.44	6.52	66.	521	93.90	6.05
69.	670	33.13	3.33	69.	595	29.78	3.74

Discussion

The 77% significant deviation of the male and female standard deviation from the HOWELLS-type mean-sigmas according to character of the combined samples unambigously proves that the comparison of the Avar-Period series — with comprising Mongoloid elements — is more appropriate with the weighted standard deviation values obtained on the basis of combining several Avar-Period series. Since the significant deviations were experienced in 81% in the case of males, and in 61% in the case of females, it is also more appropriate to calculate the weighted standard deviations for the male and female types separately, and then count with these values later on.

Table 2. Comparison of the HOWELLS-type mean sigmas and the standard deviation of the Avar sample

No. Martin	Mean sigmas (Howells)	Males			Females		
		S Avars	Diff.	Signifi-cance	S Avars	Diff.	Signifi-cance
1.	6.09	6.83	4.64	++	6.05	−0.59	−
8.	5.03	6.45	10.76	++	5.97	6.71	++
9.	4.32	4.61	2.69	+	4.28	−0.33	−
17.	5.12	5.92	5.02	++	5.60	2.90	+
45.	5.10	5.78	4.29	++	5.59	2.98	+
47.	6.33	6.84	2.56	+	6.21	−0.54	−
48.	4.28	4.65	3.15	++	4.67	3.14	++
51.	1.82	1.94	2.48	+	1.81	−0.17	−
52.	2.01	2.38	6.88	++	2.02	0.19	−
54.	1.81	1.93	2.38	+	1.99	3.37	++
55.	3.03	3.71	8.26	++	3.24	2.43	+
66.	6.62	6,52	−0.50	−	6.05	−2.76	+
69.	2.84	3.33	6.32	++	3.74	10.94	++

Remark to the significance level:
++ = highly significant + = significant − = non significant

The PENROSE-type distances provide more exact comparison.

However, depending on the distance taken as the base for clustering (of size, shape, or generalized), the degree of similarity to one another of the various series may also differ.

Despite these, we succeeded in finding such series, which on the basis of all three distances could be linked to each other at the same level.

Therefore, in the case of males, linkage at a level of 0.95% was found for all three distances, thus from the studied series, the Homokmégy and Kecel–I groups of findings were those being the most similar to each other. The findings from Madaras and Szarvas, Szekszárd and Előszállás, Kékesd occur together in all three cases. The series from Kunszállás and Mosonszentjános could be linked to each other more strongly, although their similarity to the rest of the samples is slight. Eventually, the male findings excavated at Rákóczifalva unambigously show the least similarity to every other sample.

In the case of females the findings from Homokmégy, Kecel–I and Üllő–II show the strongest linkage to each other regarding all three distances. The findings from Sükösd and Szeged–Fehértó, Madaras and Mélykút, Tiszavárkony and Adorján–A, Előszállás and Kékesd also occur together. The series belonging to the Szarvas site was the most different from the rest.

Both in the case of males and females, the group of findings from Homokmégy and Kecel–I, Előszállás and Kékesd were the most similar to each other. Therefore, sex differences could not be determined from these. At the same time, however, in the rest of the samples, various groupings were possible according to the distances calculated on the basis of the measurements of the male and female findings.

The groups received with clustering cannot be attached to geographical regions, since the connection of the series from Kunszállás and Mosonszentjános in the case of males; and the series from Tiszavárkony and Adorján in the case of females could be determined besides great, different geographical distances.

At the same time it seems that the connection of the series independent of the geographical situation.

The demonstrated results are also dependent on many collateral facts, like the degree of cemetery excavation (partial or complete), the condition of preservation of the findings, etc. Therefore, our aim could only be stricted to attempt the outlining of the relationships between certain series on a more exact base, making use of the opportunity proved by the computer — by no means with the demand to also expand the connections between the various groups of findings (population units) to genetic, ethnic, or other relationships.

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